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Multicriteria Inventory ABC Classification in an Automobile Rubber Components Manufacturing Industry

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Abstract

The automobile industry frequently uses rubber in the body structure of its components. The rubber parts contribute around 20 % of the entire body structure .Storing the inventory of the rubber components is the main problem in the automobile industry. A Multi Criteria Inventory Classification (MCIC) is one of the effective inventory classification techniques. In MCIC, various criteria and sub criteria are also considered for classification of the inventory. In this paper, the MCIC method has been proposed for the classification of the inventory of an automobile rubber components manufacturing industry. An Analytic Hierarchy Process (AHP) has been utilized for estimating the value of the inventory system. In the AHP, complex problems are categorized into various sub problems, which have been identified by using the hierarchical structure based on the criteria and attributes. Using the AHP, better inventory classification was identified for the automobile rubber components manufacturing industry. Further, this paper discusses the effective inventory control system of the automobile rubber components manufacturing industry.

Keywords : Multi Criteria Inventory Classification; AHP;Automobile Rubber Components Manufacturing Industry; Inventory classification

1. Introduction

An inventory is one of the primary drivers in a supply chain management. The inventory may be in the form of raw material, work in progress, finished goods, ware house items etc. between the supplier and customer, throughout the supply chain network. Managing these inventories is essential for any type of industry.

Nomenclature

MCIC	Muiti Criteria Inventory Classification
ADU	Annual Dollar Usage
AHP	Analytic Hierarchy Process

The automobile industry deals with many different types of components. 20% of the overall components are composed of rubber parts. The Indian rubber industry manufactures a wide range of rubber products such as of tyres, tubes, automobile parts etc. The rubber industry in India is basically divided into two sectors: tyre and non tyre sectors. In the non tyre sector automobile rubber parts have made a major contribution. These sectors comprise of small scale, medium scale and micro-scale units. Managing the inventory in these industries is a difficult task due to the absence of an inventory manager and enterprise resource planning. To overcome these issues, a simple inventory classification should be developed .Normally, The ABC analysis is used to classify the inventory items based on the ADU. It is based on the Pareto principle. In the ABC analysis, A class items contribute the majority (70-80%) of the total inventory value of the items. B class

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contributes (10-15%) and C class consist 5 % of the total inventory value of the items. However, it is not appropriate for a single criterion now a day. The inventory of an firm depends on various criteria, such as unit price, annual demand rate, critical nature,scarcity,durability etc.In the past studies, the annual demand value of a product and critical nature of the product were used to classify the items [1]. Then the criteria extended to lead time[2].The Analytic hierarchy process was used to classify the spare parts of a large manufacturing organization , based on the criticality of the parts which depends on criteria like availability, spare demand and lead time for spares procurement [3].The Genetic algorithm was used to classify the inventory items based on various criteria, like ADU,number of requests, lead time, reparability for a university stationary inventory and unit price, number of requests, lead time, scarcity, durability, substitutability, reparability, order size, and stock ability for an explosive inventory[4].In a pharmaceutical company, the Artificial neural network was used to classify the randomly selected inventory items based on the criteria, unit price, ordering cost, demand range and lead time[5].A weighted linear optimization model was proposed for the classification of inventory items based on the various criteria[6].A web based MCIC was proposed and validated with inventory records obtained from an electrical appliances company. The classification is based on criteria such as price, annual demand, blockade effect, availability, lead time and common use [7].

Hadi proposed a nonlinear programming model for MCIC considering fewer criteria, unit cost, ADU and lead time [8]. Rezari et.al. Proposed a fuzzy rule based approach for the MCIC based on the criteria, like unit price, annual demand, lead time and durability. The approach was validated with the set of 54 stock keeping units [9]. A Hadi et.al. proposed a fuzzy AHP-DEA approach for the ABC classification considering the criteria of ADU,lead time, average lot cost and limitations of warehouse space[10]. Chaen proposed an inventory classification, based on the items peer estimation value. The approach estimates the subjective nature, and considered only three criteria, like ADU, annual unit cost and lead time [11]. Torabi et.al. proposed an MCIC based on qualitative and quantitative criteria [l2].However warehouse space and shape of the items are ignored in the decision making process of the inventory classification. The warehouses of an industry have space constraints, and accessibility of item constraints in accommodating all the inventory items.

In this paper, a multi criteria inventory ABC classification has been proposed, for an automobile rubber components manufacturing industry. The classification is based on the criteria of demand, unit price, annual consumption value, unit weight, and shape of the component. An Analytic Hierarchy Process (AHP) has been utilized for estimating the value of the inventory system.The classification is based on the bin allocation of the inventory items. Further, this paper will discuss the effective inventory control system of an automobile rubber components manufacturing industry.

The rest of the paper is organized as follows: Section 2 presents the methodology applied in this paper.Section 3 contains the industry details, data collection from the industry and data analysis. Section 4 deals with the results obtained from the analysis and their discussion. Section 5 concludes the paper.

2. Methodology

2.1. Analytic hierarchy process

In 1980 Saaty developed the AHP to solve complex problems [13].AHP is widely used for the multi-criteria decision- making process. The values of the criteria are tabulated below in table1.

Table 1. The fundamental scale of the analytic hierarchy process [13].

Value a_{ij}	Description
1	Criteria *i* and *j* are equally important
3	Criteria *i* is slightly more important than criteria *j*
5	Criteria *i* is more important than criteria *j*
7	Criteria *i* is most important than criteria *j*
9	Criteria *i* is absolutely most important than criteria *j*
2,4,6,8	Middle values

It disintegrates a complex problem into sub problems in the form of a hierarchical structure. Experts judgment plays an important role in the decision making process. The AHP process normally consists of four steps; they are

(1) The complex problem is disintegrated into a hierarchical structure, based on objectives, criteria, sub criteria and alternatives.
(2) The criteria and alternatives are compared pair wise, with respect to the importance of the objective, criteria, sub criteria and alternatives, at each level of the hierarchy. Saaty's scale is used for the quantification of the pair wise comparison.
(3) The pair wise comparison results of n criteria can be summarized in a n*n comparison matrix A, using formula1.

$$A= (a_{ij}), \text{ where } i, j=1, 2, 3 \ldots n. \quad (1)$$

Using the following equation 2 the priority weights are calculated for the comparison matrix

$$A\omega = \lambda_{max}\, \omega \quad (2)$$

where A is a n dimensional comparison matrix, λ_{max} is the biggest eigen value of A and ω is the eigen vector corresponding to λ_{max}

(4) The consistency index (CI) can be calculated to evaluate the consistency of the matrix by using equation 3.

$$CI = (\lambda_{max} - n)/(n-1) \quad (3)$$

To measure the degree of CI the consistency ratio CR is calculated using the equation 4.

$$CR = CI/RI \tag{4}$$

where RI is the random index

The value of CR should be below 0.10; otherwise the procedure should be repeated to improve the consistency.

3. Industry and Data collection

3.1Industry

The industries studied in this study were manufacturers of rubber components, particularly for automobiles. The company is located in Chennai. The company is one of the leading suppliers of rubber components for major automobile industries. The various components manufactured in the industry were covers, grommets, boots, protectors etc, each product having sub groups or part families. These sub groups vary slightly in shape, part weight, manufacturing processes, colour, and their unit price.

Usually, the rubber components are lesser in weight. In the rubber component manufacturing industry, the unit weight of each component is essential for inventory classification. Usually, the rubber components are stored or handled only in various sizes of bins. Managing the components in the warehouse area is a difficult task due to the space constraint. All the inventory items in the industry were handled by three types of bins.Based on the bin usage, the inventory items were classified.

3.2. Data Collection

The monthly data of all the components were obtained from the industry for a period of one year. In the automobile rubber components manufacturing industry, the criteria of demand, unit price, annual consumption value, unit weight, and shape of the component were the important criteria for inventory control .The demand rate, unit price, unit weight and shape of all the components have been obtained from the inventory supervisor**.** The shape of the component was categorised into three, namely, regular, irregular, Awkward. The shape of the component would play a major role in bin selection, and allocating bins for the inventory items. Three types of bins were alternatives, which is used for inventory classification.

3.3. Data Analysis

The data collected has been analyzed using the Excel sheet. The overall data of the components were interpreted, and summarized based on the various criteria of the component.Saaty’s 9 point scale is used for analytic purposes. Inventory supervisor knowledge is applied in this process for decision making. Various criteria are analyzed and compared pair wise with the other criteria. After obtaining the criteria and sub criteria weigthts, the values were compared with the alternatives; .the comparison resulted in the final weights of the bin. The bins were ranked based on the high values of the weights.

3.4. Pareto Diagram

Pareto analysis is a statistical technique for decision making, which is used for selecting the limited number of tasks, which provide the significant overall effect. Pareto charts are used to display the pareto principle in arranging data from the largest frequency to the smallest , which shows the few vital factors that can be concentrated on and many trivial factors that can be ignored . Thus, the Pareto diagram is a powerful quality improvement tool. The ABC analysis was carried out using the Pareto principle. The analysis was based on the single criterion, annual usage value in rupees. The ABC analysis is the traditional method used for inventory classification.

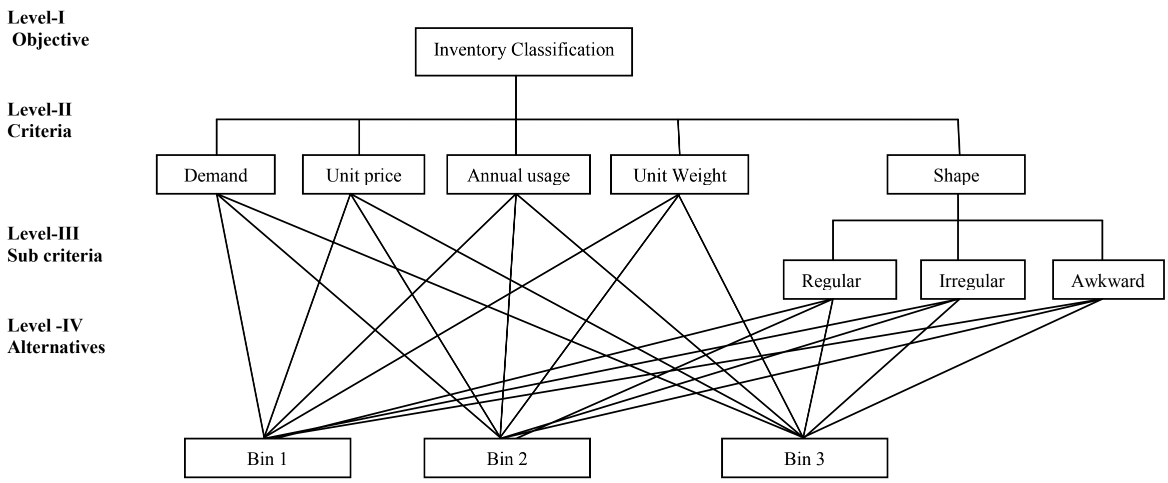

Fig.1. Hierarchy Structure of AHP

3.5. Hierarchy Structure of AHP

The hierarchy structure of AHP is shown in the Fig.1. The objective of level I is inventory classification .The criteria used for the classification of the inventory items were placed in level II.They are

(a) Annual demand of the items was quantified as the number of items.
(b) Unit price of the item.
(c) Annual usage value of the item in Indian Rupees.
(d) Unit weight of the component
(e) Shape of the component

The shape of the component is categorized into three types at level III. They are

(a) Regular shaped inventory items. These items could easily be accommodated in the bins.
(b) Irregular shaped inventory items; the storage and utilization of these items in the bin was not done fully due to their structure.
(c) Awkward shaped inventory items. The items have a low occupancy rate in the bin.

The alternatives are at level 4.It consists of different type of bins, they are

(a) Bin B1 having a cubic volume of 0.0237 m^3.The inventory items handled by bin B1 are mentioned in Table 3.
(b) Bin B2 having a cubic volume of 0.04875 m^3. The inventory items handled by bin B2 are mentioned in Table 3.
(c) Bin B3 having a cubic volume of 0.039 m^3. The inventory items handled by bin B3 are mentioned in Table 3.

4. Results and Discussion

The pair wise matrix is formulated using the AHP judgment values of the various criteria and it is structured in table 2 using (1) .From the comparison matrix the weights of the various criteria were obtained.

The relative weights of different types of criteria are calaculated using (2) and tabulated in table 2.The weight of annual usage was the highest and next was the unit weight then followed by shape, demand and unit price. From the result, it is seen that the annual usage value of the item is the highest contributor to the inventory classification. After finding the relative weights of the criteria, the weight of the sub criteria was obtained, using the same procedure. The consistency index was calculated using (3), and the λ_{max} value the level I matrix was 5.327. The consistency index value was 0.0819, and using (4) the consistency ratio was calculated as 0.079.The consistency ratio is less than 0.10 and the matrix was found to be consistent. The same procedure was applied to the other pair -wise comparison matrices and the final results were obtained

Table 2.AHP matrix for level I

Criteria	Annual usage	Unit price	Demand	Unit weight	Shape	Relative weight
Annual usage	1	6	5	2	3	0.425
Unit price	1/6	1	1/4	1/3	1/2	0.059
Demand	1/5	4	1	1/4	1/2	0.106
Unit weight	1/2	3	4	1	3	0.279
Shape	1/3	2	2	1/3	1	0.130

Table 3.Final bin weights

S.No	Bin	Weights	Rank	Class of items
1	B1	0.526098	1	A
2	B2	0.225171	3	C
3	B3	0.248731	2	B

The final weights of the three types of bins are mentioned in table 3.The weight of bin B1 was the highest, followed by B3 and B2.From the bin weight results, the inventory items are categorized into A, B, C classes, where A class items are important and should have tight control on them. B class items are less important items and C class items are of very low importantance.

Table 4. Data and results of various items

S.No	Item	Demand of the components in numbers	Unit price in Rupees (Rs)	Annual usage in Rupees (Rs)	Unit Weight in kg	Shape of the Component	Bin Allocation	ABC Classification	AHP Classification
1	R1	86490	1.5	129735	0.0041	Regular	B1	A	A
2	R3	500	2.5	1250	0.00318	Regular	B1	C	A
3	R7	26000	1.5	39000	0.00051	Regular	B1	B	A
4	R8	12500	1.12	14000	0.00619	Regular	B1	C	A
5	R10	578000	1.68	971040	0.00772	Regular	B1	A	A

S.No	Item	Demand of the components in numbers	Unit price in Rupees (Rs)	Annual usage in Rupees (Rs)	Unit Weight in kg	Shape of the Component	Bin Allocation	ABC Classification	AHP Classification
6	R12	27000	0.33	8910	0.0091	Regular	B1	C	A
7	R13	4700	1.6	7520	0.00808	Regular	B1	C	A
8	R16	3200	3.22	10304	0.0098	Regular	B1	C	A
9	R20	20000	1.33	26600	0.00353	Regular	B1	C	A
10	R21	200	2.65	530	0.00343	Regular	B1	C	A
11	R22	2900	0.66	1914	0.0037	Regular	B1	C	A
12	R23	197000	0.12	23640	0.00693	Regular	B1	C	A
13	R25	35000	0.11	3850	0.00096	Regular	B1	C	A
14	R32	50500	2	101000	0.0032	Regular	B1	B	A
15	R33	2500	0.88	2200	0.00451	Regular	B1	C	A
16	R34	11000	0.1	1100	0.00074	Regular	B1	C	A
17	R39	49000	1.75	85750	0.00675	Regular	B1	B	A
18	R40	56017	1.11	62178.87	0.01481	Regular	B1	B	A
19	R41	162	0.79	127.98	0.00826	Regular	B1	C	A
20	R42	34279	0.22	7541.38	0.004	Regular	B1	C	A
21	R43	243473	0.055	13391.02	0.00873	Regular	B1	C	A
22	R49	500	1.134	567	0.00539	Regular	B1	C	A
23	R50	3000	2.99	8970	0.00517	Regular	B1	C	A
24	R52	74500	0.31	23095	0.00509	Regular	B1	C	A
25	R56	38150	0.23	8774.5	0.0539	Regular	B1	C	A
26	R57	6000	1.134	6804	0.0075	Regular	B1	A	A
27	R62	222000	0.087	19314	0.00009	Regular	B1	C	A
28	R64	151600	0.44	66704	0.00111	Regular	B1	B	A
29	R65	4000	1.56	6240	0.00435	Regular	B1	C	A
30	R68	16500	2.1	34650	0.0014	Regular	B1	C	A
31	R5	824000	0.1	82400	0.0107	Irregular	B2	B	C
32	R6	434500	0.22	95590	0.00055	Irregular	B2	B	C
33	R9	139630	0.025	3490.75	0.00836	Irregular	B2	C	C
34	R14	70000	3.25	227500	0.00017	Irregular	B2	A	C
35	R18	272221	2.8	762218.8	0.0086	Irregular	B2	A	C
36	R19	37000	1.13	41810	0.00355	Irregular	B2	B	C
37	R24	33550	1.76	59048	0.00074	Irregular	B2	B	C
38	R27	689750	0.98	675955	0.00664	Irregular	B2	A	C
39	R28	2500	2.689	6722.5	0.00432	Irregular	B2	C	C
40	R29	287437	1.444	415059	0.0038	Irregular	B2	A	C
41	R31	7000	1.9	13300	0.00425	Irregular	B2	C	C
42	R36	132500	0.34	45050	0.00353	Irregular	B2	B	C
43	R37	67000	1.9	127300	0.00435	Irregular	B2	A	C
44	R44	114797	0.01	1147.97	0.0078	Irregular	B2	C	C
45	R45	8650	2.4	20760	0.0075	Irregular	B2	C	C
46	R47	30860	1.44	44438.4	0.00534	Irregular	B2	B	C
47	R48	112298	0.23	25828.54	0.00111	Irregular	B2	C	C
48	R54	114900	2.4	275760	0.00804	Irregular	B2	A	C
49	R66	182700	1.56	285012	0.00018	Irregular	B2	A	C
50	R67	113200	1.9	215080	0.00268	Irregular	B2	C	C
51	R69	94690	5.33	504697.7	0.0125	Irregular	B2	C	C

S.No	Item	Demand of the components in numbers	Unit price in Rupees (Rs)	Annual usage in Rupees (Rs)	Unit Weight In kg	Shape of the Component	Bin Allocation	ABC Classification	AHP Classification
52	R70	464655	2.45	1138405	0.00099	Irregular	B2	A	C
53	R2	31855	1.25	39818.75	0.01982	Awkward	B3	B	B
54	R4	70485	1.9	133921.5	0.018	Awkward	B3	A	B
55	R11	167000	0.66	110220	0.01353	Awkward	B3	A	B
56	R15	209650	1.45	303992.5	0.02122	Awkward	B3	A	B
57	R17	86557	1.33	115120.8	0.02144	Awkward	B3	A	B
58	R26	28000	0.5	14000	0.01598	Awkward	B3	C	B
59	R30	96775	1.45	140323.8	0.01363	Awkward	B3	A	B
60	R35	438500	0.45	197325	0.00451	Awkward	B3	A	B
61	R38	201000	1.11	223110	0.00478	Awkward	B3	A	B
62	R46	320	2.55	816	0.04432	Awkward	B3	C	B
63	R51	28194	0.23	6484.62	0.04684	Awkward	B3	C	B
64	R53	90620	0.22	19936.4	0.03559	Awkward	B3	C	B
65	R55	226075	2.55	576491.3	0.05159	Awkward	B3	A	B
66	R58	9500	2.99	28405	0.00435	Awkward	B3	C	B
67	R59	37640	0.99	37263.6	0.03281	Awkward	B3	B	B
68	R60	16600	1.2	19920	0.03269	Awkward	B3	C	B
69	R61	100540	0.56	56302.4	0.03537	Awkward	B3	B	B
70	R63	1100	0.09	99	0.03545	Awkward	B3	C	B

4. Conclusion

In this study, the mulicriteria inventory ABC classification is proposed, for an automobile rubber components manufacturing industry. Due to improper material allocation and inefficient inventory handling process, storing the inventory of the rubber components in a proper location and in the proper bin is the main problem in the automobile rubber components industry. The criteria, unit weight of the component, and shape of the product, are used along with the other traditional criteria for the inventory classification. The Analytic Hierarchy Process (AHP) has been utilized, for estimating the judgment of the inventory system. By analyzing the various criteria, sub criteria and alternatives, the weights are obtained for the different types of bins. Based on the usage of the bin, the inventory items are classified as A, B, C items. The resulting bin classification has easy accessibility in the warehouse.The bin traceability and utilization has also improved.

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